Regional Soil Erosion Assessment Based on Sample Survey and Geostatistics

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There is a growing understanding that land degradation is becoming one of the biggest threats to food security and sustainable agriculture, combined with a growing population and a more vulnerable climate system. Water and wind erosion are the two primary causes of land degradation (Blanco and Lal, 2008). To improve the management of soil erosion, the first step is to monitor the related system to obtain reliable and timely information, including location, distribution, frequency, severity, and dynamic factors. A sampling survey of elements from a target population has proven to be an effective tool for a natural resources monitoring network. The fourth census on soil erosion in China was conducted during 2010-2012, and was based on a stratified unequal probability systematic sampling method (Liu et al., 2013). There were a total of 32,364 Primary Sampling Units (PSUs) identified nationwide to collect factors for water erosion prediction (Liu, 2013). A Chinese Soil Loss Equation (CSLE; Liu et al., 2002) with the multiplication of seven factors including rainfall erosivity (R factor), soil erodibility (K factor), slope length (L factor), slope steepness (S factor), biology practice (B factor), engineering practice (E factor), and tillage practice (T factor) was used to estimate the soil loss for the PSUs, and a spatial interpolation model estimating soil loss (A) directly via Kriging (KRIG) was used to estimate the soil loss for the area without a field survey.

The purpose of this study was to compare five spatial interpolation models based on KRIG and a bivariate penalized spline over triangulation (BPST) to generate regional soil loss assessments. These were: Estimated A directly via KRIG (Model I), Estimated A directly via BPST (Model II), Estimated A directly by R and K via BPST (Model III), Model assisted by land use via BPST (Model IV), and Model assisted by R, K and land use via BPST (Model V).

Shaanxi Province with highly erosion-prone Loess soil was used as an example area to conduct the comparison (Figure 1). A convex hull of the boundary of Shaanxi province was generated, with a buffer area of 30 km outside of the convex hull. The rasters of R factor, K factor, and the 1:100000 land use map for the whole area were collected. PSUs located inside the whole area were used, which included 1775 units in Shaanxi Province and 1341 units from surrounding provinces.

We found that the model assisted by the R, K and land use via BPST (Model V) generated the best results, or the minimum mean squared errors (Table 1). Model II (Estimated A directly via BPST) generated lower minimum mean squared errors than Model I (Estimated A directly via KRIG), which suggested that the BPST method was superior to the Kriging method in this case. Model III and Model V performed better than Model II and Model IV, respectively, which suggested that R and K contributed some useful information. Model IV and Model V were much better than Model II and Model III, which suggested that the land use was the key auxiliary information for the spatial interpolation in the regional soil erosion assessment.

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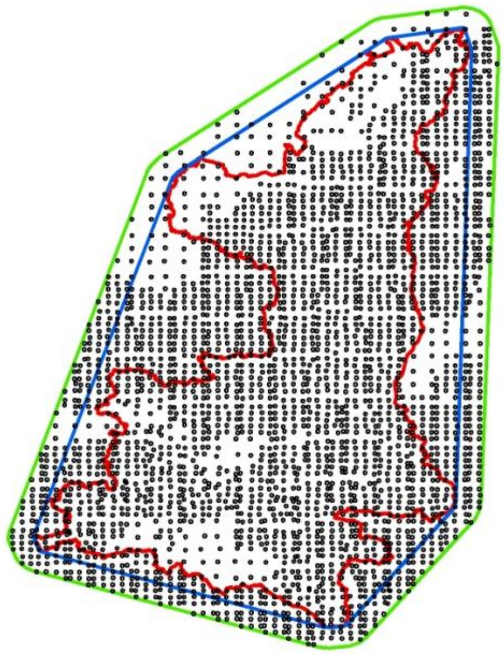

Figure 1. Distribution of PSUs (solid dots) used in this study. The red line is the boundary of Shaanxi Province, the blue line is the convex hull of the boundary, and the green line is the 30 km buffer of the convex hull.

Table 1. Mean squared errors (MSE) of predicted soil loss using KRIG and BPST for five models.

Model code	Model description	MSE
Model I	Estimated A directly via KRIG	440.66
Model II	Estimated A directly via BPST	427.75
Model III	Estimated A directly by R & K via BPST	344.79
Model IV	Model assisted by land use via BPST	170.69
Model V	Model assisted by R, K & land use via BPST	154.25

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